DETAILED ACTION

Claim Objections

1. Claim 6 is objected to because of the following informalities: The terminology, "the nozzles" lacks antecedent basis. Appropriate correction is required.

2. Claim 11 is objected to because of the following informalities: The terminology, "the CJ speed" lacks antecedent basis. Appropriate correction is required.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Regarding claim 12, the phrase "for instance" renders the claim indefinite because it is unclear whether the limitation(s) following the phrase are part of the claimed invention. See MPEP § 2173.05(d).

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

6. Claims 1, 2, 4-6, 8-12 are rejected under 35 U.S.C. 102(b) as being anticipated by Patent 5,280,705 to Epstein et al (Epstein).

In reference to claim 1:

Epstein teaches:

> *A pulse detonation engine (10) comprising a combustion chamber (14), an igniting device (col 2 lines 57-58), and a fuel injection device (20), comprising a plurality of injection valves arranged in an axial direction (col 3 lines 36-41), characterised in that the fuel injection device injects fuel into the combustion chamber (col 2 lines 1-2, Fig 1) which contains residual products after a combustion, inter alia, free radicals* (residual products in the combustion chamber does not alter or add anything to the structure of the invention; Epstein teaches a structure that anticipates applicant's structure even though Epstein does not teach residual products).

In reference to claim 2:

Epstein teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above), *characterised in that the injection valves open simultaneously to inject fuel into the combustion chamber* (col 4 lines 51-54).

In reference to claim 4:

Epstein teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above), *characterised in that the pulse detonation engine comprises more than 5 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 5:

Epstein teaches:

A pulse detonation engine as claimed in claim 1 (see rejection of claim 1 above), *characterised in that the pulse detonation engine comprises more than 18 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 6:

Epstein teaches:

A pulse detonation engine as claimed in claim 1, characterised in that the nozzles are arranged for sequence-controlled injection of the fuel into the combustion chamber (col 3 lines 46-50; Fig 4 and 5).

In reference to claim 8:

Epstein teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above), *characterised in that an injection valve inject fuel into the combustion chamber shortly before the detonation reaches the injection valve to minimise the time during which the fuel and the free radicals are mixed before the detonation front detonates the mixture* (col 1 lines 16-18, 24-26, 67-68, col 2 lines 1-2; col 6 lines 46-50; Epstein's structure capable of performing claimed operation).

In reference to claim 9:

Epstein teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above), *characterised in that the pulse detonation engine comprises more than 5 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 10:

Epstein teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above)*, characterised in that the pulse detonation engine comprises more than 18 injection valves* (Fig 8A – shows 32 injection valves)*.*

In reference to claim 11:

Epstein teaches:

A pulse detonation engine as claimed in claim 6, characterised in that the speed of the sequence control is close to the CJ speed of the mixture of fuel/air and the residual products (col 3 lines 46-50; Epstein's structure is capable of performing the claimed operation).

In reference to claim 12:

Epstein teaches:

A pulse detonation engine as claimed in claim 1 (see rejection of claim 1 above)*, characterised in that the fuel is in gaseous form, for instance hydrogen gas or acetylene, liquid form, for instance jet propulsion fuel which is injected into the pulse detonation engine as an aerosol, or solid form, for instance boron, which is injected into the pulse detonation engine in the form of a powder* (the fuel of Epstein will inherently take one of those three forms)*.*

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 1, 4-6, 8-13, and 15-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Patent 5,280,705 to Epstein et al (Epstein) in view of US Patent 5,118,281 to Bramlette et al (Bramlette).

In reference to claim 1:

Epstein teaches:

A pulse detonation engine (10) *comprising a combustion chamber* (14)*, an igniting device* (col 2 lines 57-58)*, and a fuel injection device* (20)*, comprising a plurality of injection valves arranged in an axial direction* (col 3 lines 36-41)*, characterised in that the fuel injection device injects fuel into the combustion chamber* (col 2 lines 1-2, Fig 1)

Epstein fails to teach:

which contains residual products after a combustion, inter alia, free radicals.

Bramlette teaches a pulse combustor with a combustion chamber (10) wherein combustion products mix with combustion reactants in order to achieve a certain temperature for ignition (col 5 lines 6-11 and 34-38). It would have been obvious to one of ordinary skill in the art at the time of the invention to mix the combustion reactants

with the combustion products within the combustion chamber of Epstein in order to achieve a certain temperature for ignition, as explicitly taught by Bramlette.

In reference to claim 4:

Epstein in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above), *characterised in that the pulse detonation engine comprises more than 5 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 5:

Epstein in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above), *characterised in that the pulse detonation engine comprises more than 18 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 6:

Epstein in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 1, characterised in that the nozzles are arranged for sequence-controlled injection of the fuel into the combustion chamber* (col 3 lines 46-50; Fig 4 and 5).

In reference to claim 8:

Epstein in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 6* (see rejection of claim 6 above), *characterised in that an injection valve inject fuel into the combustion chamber shortly before the detonation reaches the injection valve to minimise the time*

during which the fuel and the free radicals are mixed before the detonation front detonates the mixture (col 1 lines 16-18, 24-26, 67-68, col 2 lines 1-2).

In reference to claim 9:

Epstein in view of Bramlette teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above), *characterised in that the pulse detonation engine comprises more than 5 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 10:

Epstein in view of Bramlette teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above), *characterised in that the pulse detonation engine comprises more than 18 injection valves* (Fig 8A – shows 32 injection valves).

In reference to claim 11:

Epstein in view of Bramlette teaches:

A pulse detonation engine as claimed in claim 6, characterised in that the speed of the sequence control is close to the CJ speed of the mixture of fuel/air and the residual products

Epstein teaches that his sequenced fuel injection method promotes an optimum combustion rate (col 3 lines 46-50). The fuel is injected into the combustion chamber through the valves in a certain sequence before being combusted. It would have been obvious to one of ordinary skill in the art at the time of the invention to inject the fuel in a

sequence that is close to the detonation speed of the medium in order to achieve an optimum combustion rate, as explicitly taught by Epstein.

In reference to claim 12:

Epstein in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above)*, characterised in that the fuel is in gaseous form, for instance hydrogen gas or acetylene, liquid form, for instance jet propulsion fuel which is injected into the pulse detonation engine as an aerosol, or solid form, for instance boron, which is injected into the pulse detonation engine in the form of a powder.*

Epstein does not explicitly state the form of the fuel. However, as known in the art and by the laws of physics, the fuel must take one of only three states: gas, liquid, or solid. It would have been obvious to one of ordinary skill in the art at the time of the invention to provide fuel to be combusted in Epstein's apparatus that took a gaseous, liquid, or solid form.

In reference to claim 13:

Epstein in view of Bramlette teaches:

> *A method of initiating detonations in a pulse detonation engine* (10)*, characterised in that a fuel is injected into a combustion chamber having an axial extension* (14)*; that the fuel is injected into the combustion chamber through a plurality of injection valves arranged along the axial extension of the combustion chamber* (Fig 4; 26, 28, 30)*; that the fuel is mixed with combustion gases*

remaining in the combustion chamber and comprising free radicals, from the preceding detonation; and that the thus obtained mixture is caused to detonate.

Bramlette teaches a pulse combustor with a combustion chamber (10) wherein combustion products mix with combustion reactants in order to achieve a certain temperature for ignition (col 5 lines 6-11 and 34-38). It would have been obvious to one of ordinary skill in the art at the time of the invention to mix the combustion reactants with the combustion products within the combustion chamber of Epstein in order to achieve a certain temperature for ignition, as explicitly taught by Bramlette.

In reference to claim 15:

Epstein in view of Bramlette teaches:

A method as claimed in claim 13 (see rejection of claim 13 above)*, characterised in that the injection valves are controlled individually for the injection of the fuel into the combustion chamber* (col 3 lines 41-43)*.*

In reference to claim 16:

Epstein in view of Bramlette teaches:

A method as claimed in claim 15 (see rejection of claim 15 above)*, characterised in that the injection valves are sequence controlled at a speed close to the detonation speed of the mixture of fuel/air and the remaining combustion gases.*

Epstein teaches that his sequenced fuel injection method promotes an optimum combustion rate (col 3 lines 46-50). The fuel is injected into the combustion chamber through the valves in a certain sequence before being combusted. It would have been obvious to one of ordinary skill in the art at the time of the invention to inject the fuel in a

sequence that is close to the detonation speed of the medium in order to achieve an optimum combustion rate, as explicitly taught by Epstein.

9. Claims 7 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Patent 5,280,705 to Epstein et al (Epstein) in view of US Patent 5,118,281 to Bramlette et al (Bramlette) as applied to claim 6 above, and further in view of US Patent 5,579,633 to Hunter et al (Hunter).

In reference to claim 7:

Epstein in view of Bramlette teaches:

A pulse detonation engine as claimed in claim 6 (see rejection of claim 6 above),

Epstein in view of Bramlette fails to teach:

characterised in that the injection valves inject a fuel/air mixture into the combustion chamber.

Hunter teaches a pulse detonation apparatus wherein the fuel/air injectors provide a mixture of air, additional oxygen, and fuel to the combustion chamber (col 4 lines 10-14 and 18-21) in order to achieve a certain richness to facilitate detonation (col 4 lines 22-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to inject a fuel/air mixture into the combustion chamber of Epstein in order to achieve a certain richness to facilitate detonation, as explicitly taught by Hunter.

In reference to claim 17:

Epstein in view of Bramlette and further in view of Hunter teaches:

A method as claimed in claim 13 (see rejection of claim 13 above)*, characterised in that the injection valves inject a fuel/air mixture into the combustion chamber.*

Hunter teaches a pulse detonation apparatus wherein the fuel/air injectors provide a mixture of air, additional oxygen, and fuel to the combustion chamber (col 4 lines 10-14 and 18-21) in order to achieve a certain richness to facilitate detonation (col 4 lines 22-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to inject a fuel/air mixture into the combustion chamber of Epstein in order to achieve a certain richness to facilitate detonation, as explicitly taught by Hunter.

10. Claims 1-2 and 13-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Patent 5,546,745 to Kutschenreuter (Kutschenreuter) in view of US Patent US Patent 5,118,281 to Bramlette et al (Bramlette).

In reference to claim 1:

Kutschenreuter teaches:

A pulse detonation engine comprising a combustion chamber (14), and a fuel injection device (40a-40d)*, comprising a plurality of injection valves arranged in an axial direction* (Fig 4)*,*

Kutschenreuter fails to teach:

a*n igniting device*

characterised in that the fuel injection device injects fuel into the combustion chamber which contains residual products after a combustion, inter alia, free radicals.

Though Kutschenreuter does not specifically disclose an ignitor, he discloses burning a fuel-air mixture (col 1 lines 27-28). It is well known in the art to include an ignitor in order to initiate the burning of the fuel-air mixture. It would have been obvious to one of ordinary skill in the art to include an ignitor in Kutschenreuter's engine in order to burn the fuel/air mixture.

Bramlette teaches a pulse combustor with a combustion chamber (10) wherein combustion products mix with combustion reactants in order to achieve a certain temperature for ignition (col 5 lines 6-11 and 34-38). It would have been obvious to one of ordinary skill in the art at the time of the invention to mix the combustion reactants with the combustion products within the combustion chamber of Kutschenreuter in order to achieve a certain temperature for ignition, as explicitly taught by Bramlette.

In reference to claim 2:

Kutschenreuter in view of Bramlette teaches:

> *A pulse detonation engine as claimed in claim 1* (see rejection of claim 1 above)*, characterised in that the injection valves open simultaneously to inject fuel into the combustion chamber* (col 4 lines 50-51)*.*

In reference to claim 13:

Kutschenreuter teaches:

> *A method of initiating detonations in a pulse detonation engine* (10)*, characterised in that a fuel is injected into a combustion chamber having an axial extension* (14)*; that the fuel is injected into the combustion chamber through a*

plurality of injection valves arranged along the axial extension of the combustion chamber (Fig 4; 26, 28, 30)*;*

Kutschenreuter fails to teach:

that the fuel is mixed with combustion gases remaining in the combustion chamber and comprising free radicals, from the preceding detonation; and that the thus obtained mixture is caused to detonate.

Bramlette teaches a pulse combustor with a combustion chamber (10) wherein combustion products mix with combustion reactants in order to achieve a certain temperature for ignition (col 5 lines 6-11 and 34-38). It would have been obvious to one of ordinary skill in the art at the time of the invention to mix the combustion reactants with the combustion products within the combustion chamber of Kutschenreuter in order to achieve a certain temperature for ignition, as explicitly taught by Bramlette.

In reference to claim 14:

Kutschenreuter in view of Bramlette teaches:

A method as claimed in claim 13 (see rejection of claim 13 above)*, characterised in that all injection valves inject fuel simultaneously into the combustion chamber* (col 4 lines 50-51)*.*

11. Claim 3 is rejected under 35 U.S.C. 103(a) as being unpatentable over US Patent 5,546,745 to Kutschenreuter (Kutschenreuter) in view of US Patent US Patent 5,118,281 to Bramlette et al (Bramlette) as applied to claim 2 above, and further in view of US Patent 5,579,633 to Hunter et al (Hunter).

Kutschenreuter in view of Bramlette teaches:

A pulse detonation engine as claimed in claim 2 (see rejection of claim 2 above),

Kutschenreuter in view of Bramlette fails to teach:

characterised in that the injection valves inject a fuel/air mixture into the combustion chamber.

Hunter teaches a pulse detonation apparatus wherein the fuel/air injectors provide a mixture of air, additional oxygen, and fuel to the combustion chamber (col 4 lines 10-14 and 18-21) in order to achieve a certain richness to facilitate detonation (col 4 lines 22-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to inject a fuel/air mixture into the combustion chamber of Kutschenreuter in order to achieve a certain richness to facilitate detonation, as explicitly taught by Hunter.

Conclusion

12. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. US Patent 4,782,660 to Domyan et al. teaches a sequenced fuel injector. US Patent 5,540,583 to Keller et al. teaches a combustion system that mixes combustion reactants with combustion products.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Andrew Nguyen whose telephone number is 571-270-5063. The examiner can normally be reached on Monday through Friday 8:30 am - 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ken Bomberg can be reached on 571-272-4922. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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